St. Louis Engineer's Club.

ADDRESS OF THE PRESIDENT.

December 17, 1890.

From the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

ELECTRICAL INDUSTRIES IN ST. LOUIS.

ADDRESS BY FRANCIS E. NIPHER, RETIRING PRESIDENT OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read December 17th, 1890.]

It seems appropriate at this time to give a brief account of the progress and present condition of electric industries in our city.

The first commercial lighting that might fairly be called successful, was inaugurated by Charles Heisler in 1878 at Conrad's brewery. Alternating currents were used in operating arc lamps. Later he adopted a series system of incandescent lighting, still using alternating currents.

In England the general impression still seems to be that incandescent lamps cannot be successfully operated on long lines without the use of converters and an alternating multiple system. Such was the general opinion in this country until Mr. Heisler pushed boldly into the field and finally operated 50 miles of line wire from one dynamo. The Heisler Company, of this city manufacture only central station plants, of which about 70 have been established. The largest plant of about 5,000 16-candle lamps, is operated by the Municipal Electric Lighting Co. in this city. The total capacity of the plants established by this company is about equivalent to 60,000 16-candle lamps. These lamps require 5 amperes, 14 volts, and are said to yield 32 candles with a life of 600 hours.

The Municipal Electric Light and Power Co., which began street illumination May 1, 1890, are now operating 3,300 arc lamps of the Wood pattern, each lamp requiring 9.6 amperes, 47 volts. Of these lamps 1,400 are furnished to private customers.

These lamps are operated in 61 circuits, the longest of which is 21 miles and carries 60 lights. The total length of the lines is about 1,000 miles, the most distant lamps being 10 miles from the power house. The company has 70 60-light and 12 30-light dynamos of the Wood-Gramme pattern, furnished by the Fort Wayne Co. The area covered by their lines is about 50 square miles and the area actually illuminated is about 30 square miles. The power is furnished by six 600 horse power engines and six high speed engines of about 75 horse power. The total energy output of the plant is about 36,000 horse power-hours per day.

The steam supply system is in duplicate throughout. Independent of this double system of steam supply is an independent connection for 1,500 horse power to be used during the day when the loads are light.

The same company operates a Heisler incandescent plant, developing the equivalent of 5,000 16-candle lamps on 150 miles of line wire. At this station four high speed engines are used, with a total capacity of 700 horse power.

The Laclede Gaslight Co. also operate a Heisler plant of 814 32-candle lamps, each requiring 5 amperes, 14 volts. These lamps are used in alley lighting. These are operated in four circuits from two dynamos, of which the longest line is 26.5 miles; the shortest 16.1 miles. The total length of the four circuits is 86.4 miles and the area lighted is four square miles. For indoor lighting, the Laclede Co. operate a Brush alternating system with converters, of which the longest line is 14.1 miles. These circuits are also four in number with a total length of 35.3 miles. The system employs 41 conveiters with a capacity ot 1,245 16-candle lamps.

The power is obtained from two triple expansion Williams engines, having each a capacity of 250 horse power, and one single cylinder Westinghouse engine of 45 horse power.

There are in all at this plant two 1,000-light, three of 900-light and one 650-light dynamos, making a total capacity of 5,350 lights.

The Missouri Electric Light and Power Co. began operations Aug. 1, 1889, operating the Westinghouse system. They now have about 1255 converters in use as follows:

100	10-light	converters	1,000	Lights.
500	20-light	"	10,000	"
250	30-light	"	7,500	"
400	40-light	"	16,000	"
5	100-light	"	500	"
			35,000	

In November, 1890, the average number of lamps in operation during lightest loads was 3,000 16-candle lamps. During heaviest loads the number was 16,000 or not quite half the capacity. There are now 20 feeders leading from the station, the longest of which is five miles in length. There are eight 3,000-light dynamos, each capable of delivering 150 amperes at 1,000 volts terminal potential, and an additional dynamo of the same capacity will be added during the present month.

The Missouri Company also operate 150 miles of alley lamps, requiring about half the capacity of one of the dynamos. These lights are run in a series-multiple system, twenty 50-volt lamps being connected in series between mains at a potential difference of 1,000 volts. There are 700 of these lights on 35 lines, between three mains, and covering an area of about 12 square miles.

There are now in operation eight 300-horse power Westinghouse engines, seven of which are required at the time of heaviest load, when the indicated horse power was in November last, on the average about 1650.

During July, 1890, the indicated horse power hours per day was 11,040 and during the following November it was 19,800.

There are about 50 isolated electric lighting plants in St. Louis, having in all about 27,000 lights, and representing about 2,700 horse power. The cost of these plants is on the average $9 per lamp, or $243,000. Of these plants 38, representing 22,135 lamps, have been installed by the Edison Co. The largest plants are the Edison plant in the Exposition building, which has 5,000 lamps, and the United States plant at the Custom House, which has 1,930 lamps.

The Union Depot Railroad Co. are now operating fourteen miles of double track by electricity, using a Thomson-Houston plant. At present eight compound dynamos are in use, each capable of delivering 150 amperes at 500 volts terminal potential. When complete, twenty-two dynamos will be used, making 2,200 horse power in all.

At present 24 motor cars are run during light traffic and 34 motors and trail cars are used during the heavy traffic in morning and evening. The number of cars will be considerably increased in the near future in order to provide for the increasing traffic.

During heavy traffic with 34 cars the power required is at the rate of 10 horse power per car, and during light loads the power required is 6 horse power per car. The number of horse power hours per day is about 7,350.

The plant is supplied with four Hamilton-Corliss engines with rated capacity of 250, 350 and two of 500 horse power. At present one 500 horse power engine will operate the entire road.

The Lindell Railway Company are also introducing the use of electricity. At present 22 cars are being operated by electricity, and in a few days the entire road of about 33 miles of single track will be in operation. It is reported that when completed the number of cars will be 67. I was however, unable to obtain any definite information concerning the operations of this road.

It is interesting to turn from such extensive and important industries involving the outlay of millions of dollars and furnishing employment to an army of men, to the humble and unobtrusive beginning of all these splendid things.

On Sept. 22, 1831, Faraday wrote in his laboratory note book as follows: "I have had an iron ring made (soft iron), iron round and ⅞ of an inch thick, and ring six inches in external diameter. Wound many coils of copper round, one half of the coil being separated by twine and calico. There were three lengths of wire, each about 24 feet long, and they could

be connected as one length or as separate lengths. By trial of a trough, each was insulated from the other. We will call this side of the ring A. On the other side, but separated by an interval, was wound wire in two pieces, together amounting to about 60 feet in length, the direction being as with the other coils. This side call B.

Charged a battery of ten plates, four inches square, made the coil on B side one coil and connected its extremities by a copper wire passing to a distance and just over a magnetic needle (three feet from wire ring.) Then connected the ends of one of the pieces on A side with the battery; immediately a sensible effect on needle. It oscillated and settled at last in original position. On breaking connection of A side with the battery, again a disturbance of the needle."

Later he varied the experiment and writes:

"In place of the indicating helix our galvanometer was used, and then a sudden jerk was perceived when battery communication was *made* and *broken*, but it was so slight as to be scarcely visible. It was one way when made and the other way when broken, and the needle took up its natural position at intermediate times."

The device which Faraday describes was a transformer. The impulses which he saw in the needle were due to induced currents. He was at once led on to the invention of the first dynamo, which he constructed during the same month. But if any person had asked Faraday what practical use could be made of his discovery, he would have been utterly unable to make a satisfactory reply. The effects were so small that it was with difficulty that they could be seen. The forces were utterly insignificant. Who would then have imagined that these feeble impulses would some day be pumped through wires to light large cities and to move heavy cars loaded down with passengers? Who would have believed that articulate speech would ever be transmitted by them? Had any prophet fortold all this at that time, it would have been called the idle fancy of a useless brain. And yet these great things at once became possible when Faraday made those simple experiments. They have all followed directly from these discoveries. Probably nothing since the invention of the wagon wheel is destined to have a more profound effect upon the civilization of mankind.

At the present time the proposition to illuminate a large city by electricity would hardly be considered the dream of an enthusiast. It would be hard now to find an intelligent man so conservative that he would pronounce such a plan commercially impossible.

Eleven years ago eminent gentlemen who were in a position to know most about the merits of the project, and who were anxious to avoid making mistakes; who were also anxious (for a consideration) to prevent people from making foolish investments, were nearly all of an opposite opinion. Dynamos had indeed been built in abundance, but they could not be depended upon to maintain even the few lamps which they operated. The light was fitful, the service was uncertain. Something was always going wrong; and as for the enthusiasm which was everywhere manifest among the people, and the proprietors of dynamo machines, it was pointed

out that forty years before the inventors had precipitated a similar period of crazy excitement, and nothing had come of it.

It is certainly a bad omen if those who are in a position to know most about any project, pronounce it a hopeless case. They are generally right. In that event they seldom get credit for their wisdom, and the promoters of the schemes which they properly extinguish are always left with a feeling that the failure was due to the opposition of those who should have given support.

But the judgment of the competent is sometimes at fault and it was so in the matter of municipal electric lighting. It was left to men whose knowledge of the difficulties to be met was so limited that they were not aware of the magnitude of the problem, to do most of the drudgery and bear the burdens of the pioneer work.

Nor were these difficulties believed to be wholly of a kind that could be overcome by the ingenuity of man. The distinguished electrician of the English post service, now a well-known electrical engineer, Mr. W. H. Preece, in the January number of the *Philosophical Magazine* for 1879, gave a mathematical discussion of the problem of electric lighting. In this paper he showed, apparently to the satisfaction of everybody, that we were struggling against a law of nature. Mr. Preece assumed a given dynamo or battery having a limited or fixed electro-motive force. He assumed lamps to be connected either in series or in multiple. As the number of lamps increased, he showed that in either case the system soon approached and reached a condition where the power that could be expended on the lamp system would vary inversely as the number of lamps. The power expended in each lamp would then vary inversely as the square of the number of lamps.

This state of affairs is brought about in the series system, by the condition that the resistance of the lamp system is directly proportional to the number of lamps. The increasing resistance enfeebles the current. When the resistance of the lamp system has become so large that the dynamo resistance is inappreciable, then the effect of doubling the number of lamps is to divide the current by two. The current enters to the second power in the expression for electrical energy, so that energy and power per lamp are divided by four.

On the other hand, in the multiple system, an increase in the number of lamps diminishes the resistance of the lamp system. When this resistance becomes insignificant compared with that of the dynamo, the power is all expended in heating the dynamo. Mr. Preece gave the electric illuminators a parting blow by saying that the case was even worse than he had painted it, as he had said nothing of the power wasted in the conductors, or the heat required to bring the carbons up to a temperature of incandescence. He concludes as follows:

"We have assumed W (the total power of the dynamo) to be constant; but this is only the case when a certain limit is reached, and when the velocity of the rotating coils in the dynamo machine has attained a maximum. This limit will vary with each dynamo machine, and each kind of lamp used. With the Wallace-Farmer machine the limit appears to

be reached when six lamps are connected up in series. With the Gramme alternating machine and Jabloschkoff candles, the limit appears to be five lamps. Beyond these limits the above laws will be true. It is this partial success in multiplying the light, that has led so many sanguine experimentors to anticipate the ultimate possibility of its extensive subdivision, —a possibility which this demonstration shows to be hopeless, and which experiment has proved to be fallacious."

These conclusions obtained wide currency for about a year. While reading the paper of Mr. Preece with a view of making an exposition of the matter in a lecture, it occurred to me that the conditions assumed by Mr. Preece were not necessary—that, in fact, a series-multiple arrangement of lamps might be made and the resistance of the lamp system thus made independent of the number of lamps. It also seemed to me that dynamos might be coupled in multiple or in series, and although I then wrote the equations and drew the efficiency curves for such a plant, I did not publish the results. I had had no practical experience with dynamos, and was not sure that they would operate when connected together like battery cells.

The publication of the series-multiple arrangement for a lamp system put an end to the idea that had gained currency on the publication of Mr. Preece's paper. The system of alley lighting used by the Westinghouse company in this city, is, so far as the arrangement of lamps is concerned, exactly the one which was shown to be possible in my paper of Dec. 31, 1879.

As we now look back on the crude ideas that we all held in the early days of electric lighting, it seems incredible that so much labor, and such vast sums of money should have been expended in learning what seems so plain and simple now.

There was no error in the equations of Mr. Preece. His conclusions seemed to be justified by what was then known, but as Mr. Huxley has said, "the grist one gets from a mathematical mill, depends upon what one puts into it." The fact is we are doing exactly what Mr. Preece said was hopeless; but in a somewhat different way from the ones then in his mind. We have self-regulating dynamos, which within certain limits will maintain constant currents through the lamps as lamps are switched in and out; and the capacity of dynamos is now ten times as great as in 1879. Still these dynamos can be overloaded, and they will then behave just as Mr. Preece said they would. On account of the increased capacity of dynamos it is not as serious a matter as Mr. Preece thought it would be to finish the task by the duplication of dynamos.

During the whole progress of the electrical industry, it has been most instructive to see how some new improvement has sometimes changed the whole aspect of affairs, as when reserve troops are thrown into a doubtful contest. Plans and machinery which the prudent and conservative engineer had decided to be valueless, came then to the front, and the struggle of contending interests began on new ground and along new lines.

For example, Faraday invented the transformer or converter in 1831. It was an iron ring upon which his primary and secondary wires were

wound. Ruhmkorff and Ritchie in their well-known induction coils, showed how to convert a large current of low potential into a small current of high potential, and at the same time used a laminated core composed of a bundle of iron wires.

Then it was discovered that the induction coil is reversible, and that a small current of high potential can be converted into a large current of low potential.

It is interesting to observe that in 1883 the U. S. Patent Office refused a patent to Bernstein for a converter, on the ground that he could not possibly get out of the converter on the secondary wire, a larger current than he put into it on the primary. In 1886 the same office gave Gaulard and Gibbs a patent for the same device,* the impossible having meanwhile become possible. Then came the great step of placing the iron around the primary and secondary coils, instead of within them. This was what brought it to the front as the powerful ally of the alternate current dynamo which then became the formidable competitor of the secondary battery.

In a similar way the work of Dr. Wellington Adams of this city on the equipment of electric motor cars brought about a complete revolution in their construction. When his paper read before this club April 23, 1884, was published, the building of electric locomotives like those of Siemens and Edison wholly ceased. The entire subsequent development of the electric railway has proceeded along the lines which Dr. Adams laid down. The application of the power directly to individual car axles, centering the motor and its gearing upon the axle, so that different axles may move independently without deranging the gearing, the provision for the oscillation of the field on the car axle as an axis, while held in position by elastic resistance, all this was first done in our city, and was first proclaimed to the public by Dr. Adams in a meeting of this club.

Over and over again have we learned that we should have a watchful eye upon those things which have no practical value. Students and engineers alike are prone to ignore with systematic deliberation, those things which have no commercial value. But the history of scientific discovery and of engineering progress is simply a history of the work of men who applied their brains to useless things and made them useful; who successfully did what had been considered hopeless or had been overlooked as worthless.

In Compte's Positive Philosophy a rather positive statement is made to the effect that while the forms and distances of the heavenly bodies might be determined, "we can never know anything of their chemical or mineralogical condition." What Compte doubtless had in mind was that chemists would never get their hands on any samples of these bodies for treatment in test-tubes. But something unexpected happened. Physics came to the aid of chemistry, and star analysis became possible without the necessity of carting specimens to Paris.

It must be confessed, however, that this kind of work—the doing of

---

*Thompson's Dynamo electric Machinery.

"impossible" things—is not for all men. Within rifle shot from this place there are men who are trying to execute the plan, of driving a dynamo by a steam engine the steam for which is to be produced from heat developed by the driven dynamo. No amount of explanation can make such people understand why this is impossible, or that the combination would be absolutely devoid of commercial value, even if it could be made to succeed to perfection.

Nor do I wish to ignore the fact that the commercial instincts of mankind should be considered, in deciding what is to be undertaken. No company of business men should be willing to expend all of their capital in convincing themselves that the undertaking might have succeeded, if they had had a few more millions of capital and a few hundred years of time.

It is not an easy thing to draw the line between the cranks and the engineers. Different people draw the line in different places. It is a matter of individual judgment. Time and the march of events have frequently made it necessary to revise or reverse such judgments. We pass by imperceptible stages from the well-marked engineering lunatic, who is trying to make an engine or a dynamo drive itself, and who seems to have an idea that it will also be able to drive anything and everything else in the universe that needs driving, to the man who believes he can operate street-cars or illuminate great cities by electricity; that he can telegraph through ocean cables and drive ships and railway cars by steam.

Fortunately or unfortunately, men do often make mistakes in deciding what they should undertake. They spend their lives or their fortunes in trying to do things before the times are ripe, and while the difficulties are too great. They achieve only a partial success, which commercially is no success, and those who follow them, enjoy the benefits of their labor, and finally not only reap the pecuniary reward but monopolize all of the glory.

The data concerning the electric plants has been kindly furnished by Messrs. Emerson McMillen of the Laclede Gas Light Co., John Scullen of the Union Depot Railway Co., S. M. Dodds of the Missouri Electric Light and Power Co., and James I. Ayers of the Municipal Electric Light and Power Company. Mr. E. F. Horn, Agent of the Edison Co. furnished most of the data concerning isolated plants. To all of these gentlemen I am indebted for many courtesies. F. E. N.